A new approach for spacecraft fault management

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Introduction

The IV&V program identified a need to address software-centric safety analysis and assess the quality of software safety engineering early in the development of a system of systems to ensure the software manages safety requirements while not introducing system hazards. IV&V has created a process which depicts how a mission specific dependability and safety case is transformed to a generic dependability and safety case which can be reused for any type of space mission with an emphasis on software fault conditions and can also be applied to an industry.

Phase I - the specific model (completed)

A safety case study was conducted for a science satellite mission. Requirements validation and a system reference model was developed . Figure 1 portrays the IV&V analysis process created and followed. Figure 2 is a high-level depiction of the safety case which maps high-level safety requirements and lower-level safety requirements.

Safety case analysis

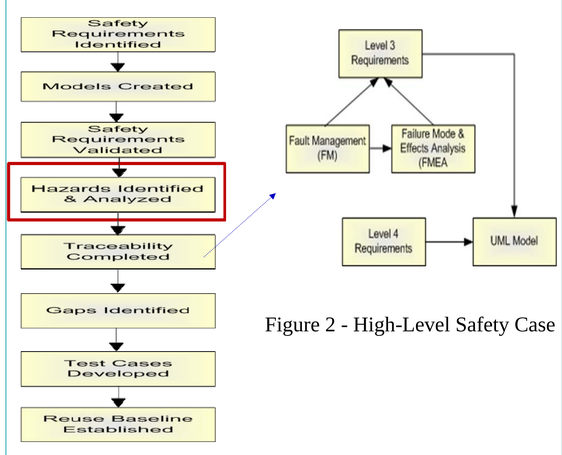


Figure 1 - IV&V Analysis Process

Figure 2 - High-Level Safety Case

Figure 3 is an example of an activity diagram which depicts a high-level overview of fault management for a safe-hold event for a specific science mission. Each subsystem is comprised of specific devices in which specific failures would result in a safe-hold event.

Mission specific fault management

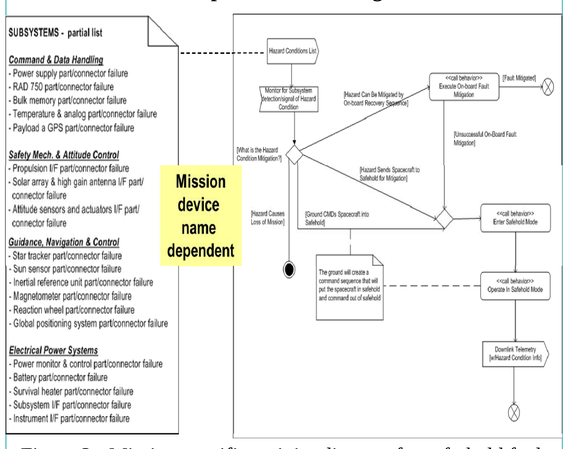


Figure 3 - Mission specific activity diagram for safe-hold fault management

Phase II - from specific to generic (current)

Fault conditions for the Phase I science mission were device dependent. When comparing space missions to each other, it was immediately obvious that all missions share many of the same characteristics - regardless of the mission's purpose.

Instead of focusing on the specific subsystem device with a specific fault, the focus will be on the functionality of a specific subsystem (Figure 4) with the fault conditions captured at a high and generic level to more easily be reused across other future missions.

Focus on functionality - not devices

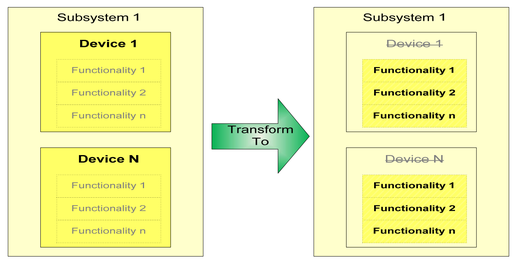


Figure 4 - Change the focus

Focus on the functionality of a specific subsystem (Figure 5) with the fault conditions captured at a high and generic level to more easily be reused across future missions. The generic behavior faults and related hazard management can be detailed later as the knowledge of the subsystem and its needs are discovered. The process in Figure 6 is used to identify and communicate generic fault condition candidates.

Look for common functionality

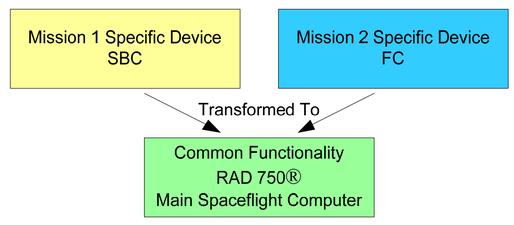


Figure 5 – Identifying common functionality

Reusable fault identification process for any mission

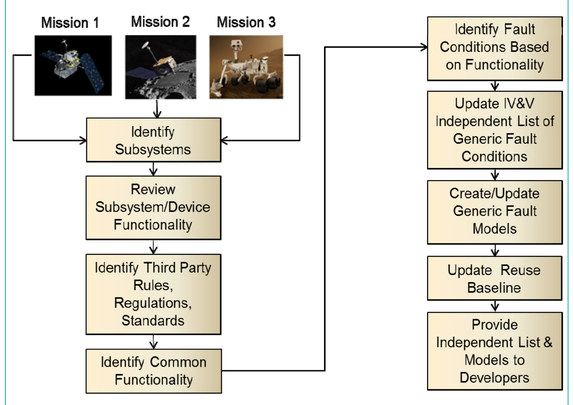


Figure 5 - Process for identifying generic fault conditions

Figure 7 transforms Figure 3 into a generic model of fault management that can be applied to any space mission. Device names were replaced with the functionality of each subsystem which also account for software as well as hardware issues. The activities were modified to include faults of any kind, and are generic enough to be applied to and modified by any mission developer.

Reusable fault management for any mission

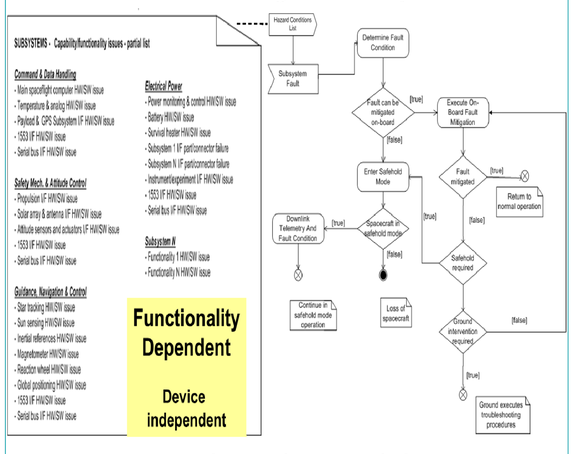


Figure 7 - Activity diagram for generic fault management

Applying the process to any industry

Your organization can apply similar fault management techniques even if your projects do not have the system of systems complexity (Figure 8). Replace the space mission examples with your system information. Decompose the system into subsystems (Figure 4) with a focus on subsystem functionality. Don't think spaceflight – think your business (Figure 9).

Industry applications

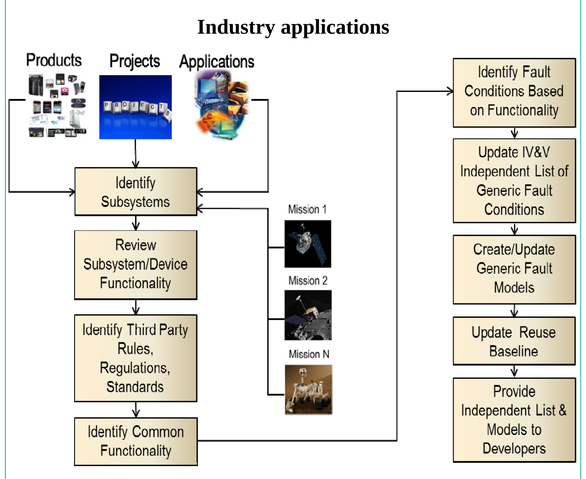


Figure 8 - Applying Phase II to your project

Change your thinking

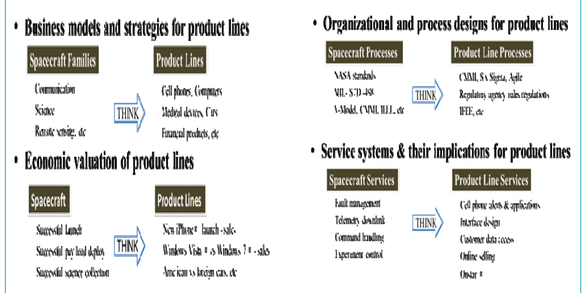
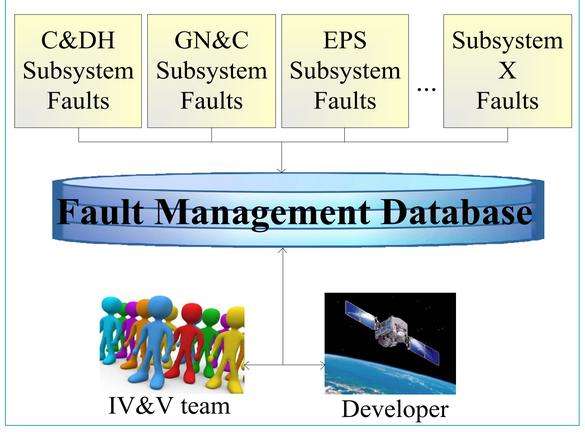


Figure 9 - Thinking about the same thing in a different way

Future direction - fault management tool

Develop a fault management database containing system/subsystem faults maintained by IV&V with support from satellite developers.

Dependability and safety through tools



Benefits to IV&V and developer

1. Enhanced validation against a list of known faults
2. Improved quality of analysis
3. Improved quality of TIMs
4. Improved quality of safety data
5. Enhanced communication with the developer
6. Quicker identification of missing requirements and faults
7. Enhanced mission dependability and safety
8. Improved overall mission success

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